necessary to modify this target through adaptive management.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to upgrade screening at diversions with ineffective screening. Where existing screening has proven less than effective and entrainment problems continue, immediate action should be taken to upgrade screens.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to reduce diversions when and where juvenile salmon are present in large or significant numbers. Even with screens, some diversions may pose a threat to young salmon and steelhead, and it may be necessary to modify operations of the diversion. Such determinations will be made after necessary monitoring and evaluation, and on a case-by-case basis. Decisions will be made with agency and stakeholder involvement and with consideration given to appropriate alternatives.

PROGRAMMATIC ACTION 1D: Promote and support relocating water diversions and developing alternate methods of supplying water from the Sacramento River that protect fish but also minimize conflict with maintaining dynamic fluvial processes.

RATIONALE: *Juvenile chinook salmon, steelhead, green and white sturgeon, Sacramento splittail, and American shad are lost at water diversion sites all along the Sacramento River during the spring-to-fall irrigation season. (Note that diversion losses include direct loss into unscreened diversions and other losses associated with the screened and unscreened intake facilities, such as from predators, including squawfish and striped bass.) Reducing entrainment losses to minimal levels is a reasonable target for the short term, given the existing poor health of many of the fish populations that use the Sacramento River and its tributaries for spawning and rearing of young. Emphasis should be on the upper river above Chico Landing, because this is the reach where winter-run chinook young rearing coincides with the spring-to-fall irrigation season.*

Determining which diversions need to be screened will be based on appropriate monitoring and evaluation, with decisions made with agency and stakeholder involvement, and with consideration given to appropriate alternatives. Actions will be taken on a case-by-case basis, with consideration given to results of pilot experiments to determine technical feasibility and cost-effectiveness of screening diversions of different size, type, and location. Priority will be given to screening diversions that pose the most threat and where screening has been determined to be effective. Emphasis should be given to projects that include the consolidation of several diversion points to a single location.

In application, priority for screening diversions will be based on several criteria including but not limited to the geographical location, the volume of water diverted, the location of the intake in the water column, and the cost effectiveness of the installation. Alternatives to screening will be considered. When a fish screen is installed, it should be tested to determine that it can perform to the criteria of the fish regulatory agencies. After testing has indicated that the screen meets the criteria, monitoring should be conducted to ensure that the screen can meet the criteria under the range of hydrologic conditions expected at the site. When operation monitoring indicates that everything is working satisfactorily, the diverter should routinely inspect the screen to ensure that the facility is undamaged.

DAMS AND OTHER STRUCTURES

TARGET 1: Minimize survival problems for adult and juvenile anadromous fish at RBDD by permanently raising the gates during the non-irrigation season and improving passage facilities during the irrigation season (◆◆◆).

PROGRAMMATIC ACTION 1A: Upgrade fish passage facilities at the RBDD.

TARGET 2: Reduce blockage to fish migrations at the ACID dam (◆◆).

PROGRAMMATIC ACTION 2A: Upgrade fish passage facilities at the ACID dam.

RATIONALE: *At present, the RBDD gates are in the raised position from September 15 through May 14, allowing free passage to about 85% of the spawning run (based on average run timing from 1982-1986). This may have reduced the number of redds (spawning nests created by salmon) being built below the dam. The remaining portion of the run migrating upstream after May 15 is likely to be delayed or blocked from passing the dam.*

Adults that are obstructed from passing the dam are forced to spawn downstream where temperature *conditions are typically unsuitable during the spawning and incubation period. Temperatures of 56°F usually cannot be maintained below RBDD without severely depleting Shasta carryover storage during the winter-run chinook incubation period; eggs and larvae usually have 100% mortality.*

Adults that must make repeated attempts to pass the dam, but eventually are successful, undergo physiological stress that may contribute to their reduced fecundity. Because migration of these adults is delayed, the fish are likely to spawn farther downstream where suitable temperatures for spawning and incubation may not be attainable.

Adult chinook salmon must negotiate fish ladders at the ACID dam during the irrigation season (typically April through November) to reach upstream spawning habitat. However, an antiquated ladder on the east abutment of the dam is ineffective in providing safe passage, and a recently installed denil ladder on the west abutment has proved only marginally successful. The ladders at this facility do not provide suitable flows to attract adults, and the ladders are not easily adjustable to compensate for varying flow conditions. A feasibility study is being conducted by the ACID to identify, develop, and evaluate alternatives to resolve adult passage problems.

LEVEES, BRIDGES, AND BANK PROTECTION

TARGET 1: Construct setback levees along leveed reaches of the river as part of the stream meander corridor (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program, consistent with flood control requirements, to evaluate potential sites for establishing setback levees along leveed reaches of the Sacramento River.

RATIONALE: *Levees, bridges, and bank protection structures inhibit overland flow and erosion and depositional processes that develop and maintain floodplains and allow stream channels to meander. Levees prevent flood flows from entering historic floodplains behind levees, stopping evolution of floodplain habitats dependent on overbank flows. Confinement of flood flows to channels by levees and bank protection structures also increases the fluvial energy of flows that scour or incise channel beds and reduces or halts the rate of channel migration and oxbow formation.*

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Reduce the area of invasive non-native woody species, such as giant reed (i.e., Arundo or false bamboo) and salt cedar (Tamarisk), that compete with native riparian vegetation (◆◆).

PROGRAMMATIC ACTION 1A: Implement a program along the length of the Sacramento River to remove and suppress the spread of invasive non-native plants that compete with native riparian vegetation.

PROGRAMMATIC ACTION 1B: Implement a program eliminates invasive woody plants that could interfere with the restoration of native riparian vegetation.

RATIONALE: *Invasive non-native plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those of competition for nutrients, light, and space. The prescribed actions are primarily to improve habitat for many fish and wildlife species and to support foodweb functions by establishing extensive riparian habitat along the Sacramento River. In most cases, the removal of invasive plants will require the replanting of native vegetation to maintain adequate levels of herbaceous cover, canopy closure, habitat structure, and to limit exotic recolonization.*

PREDATION AND COMPETITION

TARGET 1: Reduce the adverse effects of predatory fish by identifying and eliminating human made in-stream structures or operational conditions that allow unnatural predation rates (◆◆).

PROGRAMMATIC ACTION 1A: Selectively evaluate areas and make physical changes to structures in the Sacramento River, such as bridge abutments, diversion dams, rip-rap banks, and water intakes, that currently may attract predators and provide them with additional advantages in preying on juvenile salmon and steelhead. Pilot studies and evaluations are needed to determine the types of changes required and the potential degree of implementation.

RATIONALE: *Upgrading fish passage facilities at the two diversion dams will reduce delays to upstream migrating winter-run chinook salmon and hindrance of downstream migrating juvenile winter-run chinook salmon. This will contribute to a reduction in predation rates on young fish.*

During operation of RBDD, juvenile chinook are adversely affected while approaching the dam, passing the dam, and moving downstream of the dam. As juveniles migrate toward the dam, they experience increased predation in Lake Red Bluff from predatory fish and birds. Juveniles passing under the lowered dam gates become disoriented because of high water velocities and turbulence, and are subject to heavy predation downstream by squawfish and striped bass. Juveniles bypassed around the dam through the Tehama-Colusa fish bypass system may have improved survival rates because of new facilities and positive-barrier fish screens, but complete evaluations are needed.

To help protect winter-run chinook from predation and other losses associated with passage at RBDD, the dam gates have been raised for varying durations since the end of 1986. Juvenile chinook suffer mortality in passing the dam from squawfish and striped bass predation and disorientation or injury when passing beneath the dam gates or through the fish bypass system. Under the present schedule of gate operations, about 26% of the juvenile outmigrants must pass the dam when the gates are lowered and are susceptible to mortality associated with that passage. In a 1988 study, juvenile hatchery salmon were released above and below the dam to estimate total mortality during dam passage. In all, 16% to 55% fewer fish were recaptured from the releases made above dam than those made below. USFWS determined predation, primarily by squawfish, as the major cause of mortality to juvenile salmon migrating past the dam, whereas the number of deaths from physical injury received while passing under the dam were minor.

CONTAMINANTS

TARGET 1: Reduce losses of fish and wildlife resulting from pesticide, hydrocarbon, heavy metal, and other pollutants in the Sacramento River (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to remedy heavy metal pollution from IMM to meet basin plan standards, and implement reliable and proven remedies that ensure continued treatment and control of heavy metal waste before water is discharged to the Sacramento River.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to eliminate scouring of toxic, metal-laden sediments in the Spring Creek and Keswick Reservoirs.

PROGRAMMATIC ACTION 1C: Control contaminant input to the Sacramento River system by constructing and operating stormwater treatment facilities and implementing industrial best management practices (BMPs) for stormwater and erosion control.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to assess and monitor contaminant input from agricultural drainages in the Sacramento River watershed.

RATIONALE: *Note: Actions proposed here to reduce the adverse effects of contaminants in the Bay-Delta system will be coordinated with recommendations and actions developed by the CALFED Water Quality Common Program.*

The drainage from inactive mines on the IMM Superfund site represents the largest source of pollutant discharge to the Sacramento River. This discharge is at least equal to all the combined industrial and municipal discharges of dissolved metals to the San Francisco Bay and estuary system. This mine water is among the most acidic in the world and contains extremely elevated concentrations of copper, zinc, cadmium, and other metals known to be toxic to fish and wildlife. On occasion, fish deaths (including salmon) may have occurred as toxicity levels have been exceeded and documented in the upper Sacramento River as a result of IMM waste. More frequently, there are documented instances of metal concentrations that exceed toxic levels considered safe for early life stages of salmon.

The wastes from IMM, located in the Spring Creek watershed, are collected in the Spring Creek Reservoir and metered out into the releases of clean water from Shasta and Whiskeytown Reservoirs to achieve the best water quality possible. However, because of the extremely large waste load (averaging more than 1 ton of copper and zinc per day), it has not always been possible to consistently attain the water quality *objectives for copper, cadmium, and zinc in the basin plan, and interim criteria have been established until pollution control is completed. Highly toxic conditions are exacerbated when heavy winter rains induce uncontrolled spills from Spring Creek Reservoir, and flows from Shasta and Whiskeytown Reservoirs are not made available for dilution because of other CVP constraints.*

Within the lower portion of the IMM site, remediation must be developed for the metal sludge deposits in Spring Creek Reservoir and in Keswick Reservoir adjacent and downstream of the Spring Creek power plant tailrace. Preliminary monitoring in the Keswick Reservoir has documented that the sludge is highly toxic and that the deposits are extensive and up to 15 feet thick. Under certain conditions, flows from the Spring Creek power plant can mobilize large quantities of the sludge into the river, creating an acute toxicity risk to aquatic species. The sludge deposits can also contribute to chronic toxicity when combined with other sources.

Major sources of pollution include industries, municipalities, and agriculture, which discharge such contaminants as herbicides, pesticides, organic compounds, inorganic compounds, and warm water. Pollution is described as originating from point sources, such as discharge pipes or other localized sources, or from nonpoint sources, which are dispersed. Individual sources of nonpoint pollution may be insignificant, but the cumulative effects can be significant and can contribute high levels of pathogens, suspended solids, and toxins. Major contributors of nonpoint-source pollution to the Sacramento River, Sacramento-San Joaquin Delta, and San Francisco Bay include sediment discharge, stormwater and erosion, and agricultural drainage. Mandatory performance standards are needed for these sources, with flexibility granted to landowners to adopt whatever management practices are best suited for local conditions.

A primary point source of pollution is from municipal treatment plants, which release heavy metal contaminants, thermal pollution, pathogens, suspended solids, and other constituents. Implementing enhanced treatment, pretreatment programs, and tertiary treatment should help to reduce contaminant input.

Sediments constitute nearly half of the materials introduced into rivers from nonpoint sources, such as plowed fields, construction and logging sites, and mined land, and are mainly generated during storm events. Stormwater runoff in urban and developing areas is another major source of sediments and contaminants. Sedimentation from nonpoint sources should be reduced by implementing BMPs for urban and nonurban pollution, and implementing appropriate treatment and technological options that reduce pollutant loads.

An assessment of water quality and impacts from various other agricultural drainages to the Sacramento River is needed. Results from these evaluation programs should generate recommendations for corrective actions. Top priority should be given to the Sutter Bypass, which receives drainwater from rice growing areas and has outflows equivalent to those from the Colusa Basin drain. Assessments should also be conducted on Butte Slough, Reclamation District 108, and Jack Slough.

HARVEST OF FISH AND WILDLIFE

TARGET 1: Reduce illegal harvest of fish species to a minimum to maintain or increase populations by increasing enforcement efforts by 50 to 100% (◆◆◆).

PROGRAMMATIC ACTION 1A: Increase enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to educate the public on the threats to populations from illegal harvest. Various actions include ad campaigns, signs along streams, and various types of outreach programs to schools, watershed conservancies, and groups.

PROGRAMMATIC ACTION 1C: Provide additional funding for the poaching hotline and rewards for arrest and convictions of poachers.

TARGET 2: Manage the legal harvest of chinook salmon, steelhead, and sturgeon by shifting harvest from natural stocks to hatchery-reared stocks, where possible, or reducing harvest of wild stocks until the naturally produced populations recover (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to mark all hatchery salmon, allowing selective harvest of hatchery fish, while limiting harvest of wild fish. This action should be implemented on a short-term and experimental basis to ensure that it meets its objective and is cost-effective.

PROGRAMMATIC ACTION 2B: Encourage regulatory agencies to change fishing regulations (i.e., by restricting seasons, limits, and gear and reducing harvest of wild fish) to reduce legal harvest and any ancillary effects of fishing gear or techniques further. Restrictions should be severe in the short term. Long-term restrictions would depend on response of populations and effectiveness of restrictions and the degree of effectiveness of the action.

RATIONALE: *Some populations of salmon and steelhead in the Sacramento River are at such depressed levels that drastic reductions in any factors that contribute to mortality are necessary. Harvest management policies have been established by state and federal agencies to minimize mortality on natural chinook stocks, including severe harvest restrictions and size limits. Illegal harvest is known to occur along the Sacramento River. This target will be subject to adaptive management. Mass marking of hatchery steelhead began in 1997 and it should be continued.*

ARTIFICIAL FISH PROPAGATION

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead in the upper Sacramento River will stray into non-natal streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the costs and benefits of limiting stocking of hatchery-reared salmon and steelhead in the upper Sacramento River. Stocking may be reduced in years when natural production is high in selected populations.

TARGET 2: Limit hatchery stocking to populations that cannot be sustained through natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment winter-run, spring-run, and late-fall-run chinook salmon and steelhead with hatchery-produced smolts during the short-term rebuilding phase of restoration efforts and only when alternative measures are deemed insufficient to provide recovery of the populations. Stocking of hatchery-reared fish will be undertaken as experiments and adjusted or terminated as necessary, depending on results.

TARGET 3: Employ methods to limit straying and loss of genetic integrity of wild and hatchery supported stocks (◆◆◆).

PROGRAMMATIC ACTION 3A: Rear salmon and steelhead in hatcheries on natal streams to limit straying. If hatchery augmentation of Sacramento River populations of salmon and steelhead is necessary, then hatcheries should be built on the Sacramento River for that purpose.

PROGRAMMATIC ACTION 3B: Limit stocking of salmon and steelhead fry and smolts to natal watersheds to minimize straying that may compromise the genetic integrity of naturally producing populations.

TARGET 4: Minimize further threats of hatchery fish contaminating wild stocks of salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 4A: Where hatchery production is underway and continues, methods should be adopted and improved for the selection of an appropriate cross section of the adult population for spawning at the hatchery.

PROGRAMMATIC ACTION 4B: Select spawning adults of appropriate genetic makeup to minimize genetic contamination of existing hatchery and naturally producing stocks of salmon and steelhead. Given the present difficulty of determining genetic makeup of spawning adults selected for hatcheries, this action will necessarily be experimental. Hatchery-reared adults may be preferentially selected or not selected if they are adequately marked or tagged, or have other identifiable feature. Other methods may be developed to genetically categorize naturally produced or hatchery fish.

RATIONALE: *In watersheds such as the Sacramento River, where dams and habitat degradation have limited natural spawning, some hatchery supplementation may be necessary to sustain fishery harvest at former levels and to maintain a wild or natural spawning population during adverse conditions, such as droughts. However, hatchery augmentation should be limited in extent and to levels that do not inhibit recovery and maintenance of wild populations. Hatchery-reared salmon and* *steelhead may directly compete with and prey on wild salmon and steelhead. Straying of adult hatchery fish into non-natal watersheds may also threaten the genetics of wild stocks. Hatchery fish may also threaten the genetic makeup of stocks in natal rivers. Some general scientific information and theory from studies of other river systems indicate that hatchery supplementation may limit recovery and long-term maintenance of naturally producing populations of salmon and steelhead. Further research and experimentation are necessary to determine the degree to which this issue is addressed. Long-term hatchery augmentation of healthy wild stocks may genetically undermine that stock and threaten the genetic integrity of other stocks. Spawning and rearing habitats are limited, and adverse conditions may occur in drought or flood years that would undermine the population without additional hatchery production.*

Release of hatchery-reared fish into the upper Sacramento River and its tributaries could lead to a loss of the genetic integrity of wild salmon and steelhead populations. Adults straying into non-natal streams may interbreed with a wild population specifically adapted to that watershed, possibly leading to the loss of genetic integrity in the wild population. Although some irreversible contamination has occurred in salmon and steelhead populations, measures are necessary to minimize further deterioration of contaminated populations and to protect populations that are not contaminated.

Recent returns to CNFH of fall-run chinook salmon seem to indicate that the hatchery is heavily supporting the entire fall-run population, particularly in Battle Creek, all of which probably originated from CNFH. A recent estimate for the rest of the Sacramento River above RBDD, excluding Battle Creek, was only 40,000 fish, which may also have been heavily supported by CNFH production.

Some stocking of hatchery-reared fish may be necessary in the short term to rebuild naturally spawning populations; however, there is a lack of consensus among agencies and stakeholders as to the degree of stocking that is detrimental or necessary to sustain sport and commercial fisheries. This action will necessarily be short term and experimental, with subsequent efforts dependent on results and effectiveness.

Additionally, the relationship of the resident rainbow trout of the mainstem Sacramento River below Keswick (a.k.a. "river trout") with hatchery and naturally spawning steelhead populations should be investigated. There is a substantial number of large, steelhead-sized resident rainbow trout in the upper Sacramento River, and it is unknown if these fish comprise a discreet population, are a component of the steelhead/rainbow trout population, or an artifact of artificial production. The large number of non-migratory rainbow trout may be a result of ecological conditions that exist in the tailwater reaches below dams, and this needs to be investigated.

STRANDING

TARGET 1: Eliminate the straying, stranding, and loss of adult chinook salmon and other species along the Sacramento River (◆◆).

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of preventing adult chinook salmon from straying into the Colusa Basin Drain.

RATIONALE: *The straying of adult chinook salmon into the Colusa Basin Drain has long been recognized as a problem. Recent water use practices in the basin have greatly reduced the volume of discharged water, which has reduced the high water temperature and contaminant problems. Still, fish have direct access to the drain under certain flow conditions. This action is consistent with actions described in the Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997) and the Department of Fish and Game anadromous fish restoration plan (California Department of Fish and Game 1993). The feasibility should evaluate water use practices, redirection of waste water, and alternative structures to eliminate entry into the drain.*

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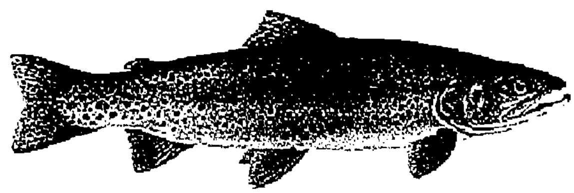
◆ North Sacramento Valley Ecological Management Zone



Introduction

The health of the North Sacramento Valley Ecological Management Zone contributes to the health of the Sacramento-San Joaquin Delta in many ways. Ecological processes within this zone contribute sediment, nutrients, and streamflow to the Sacramento River. They also provide important migration, holding, spawning, and rearing areas for spring-, fall-, and late-fall-run chinook salmon steelhead, lamprey, and native resident fish species. Many streams in this zone also provide seasonal non-natal rearing for juvenile steelhead and chinook salmon. Riparian and shaded riverine aquatic habitats provide for many terrestrial species, including neotropical birds, amphibians, and invertebrates.

The North Sacramento Valley Ecological Management Zone encompasses the geographic area and tributary streams generally surrounding the City of Redding and includes the following ecological management units:

- Clear Creek Ecological Management Unit
- Cow Creek Ecological Management Unit
- Bear Creek Ecological Management Unit, and
- Battle Creek Ecological Management Unit.

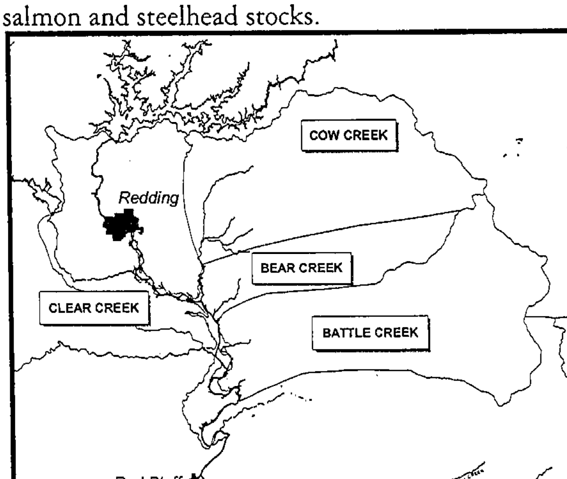
Description of the Management Zone

This ecological management zone provides habitats for a significant variety of fish, wildlife, and plant communities, including spring-, fall-, and late-fall-run chinook salmon, steelhead trout, lamprey, native resident fish, neotropical migratory birds, and native anuran amphibians.

Important ecological processes and functions shared by the individual ecological units of the North Sacramento Valley Ecological Management Zone include their respective streamflow patterns and capacity for natural sediment transport; stream meander; gravel recruitment; and stressors, such as water conveyance structures, water diversion, and invasive plant species.

Opportunities to maintain or reactivate these processes and functions are constrained to varying degrees because of past and existing human activities, such as dam construction and gravel extraction from the active stream channel. Many of these constraints are described as stressors that impair ecological function and the creation and maintenance of habitats or that cause direct mortality to important species.

The construction and operation of Whiskeytown and McCormick-Saeltzer dams and past large-scale gravel extraction activities constrain ecological processes and functions in the Clear Creek Ecological Management Unit. Ecological processes and functions on Cow and Bear creeks are impaired by alterations to the runoff pattern resulting from water diversions and land use practices. Small hydropower projects, water diversion and water diversion structures constrain ecological processes and functions on Battle Creek. Past and current operation of Coleman National Fish Hatchery on the lower section of the creek further impairs opportunities to improve the distributions of wild salmon and steelhead stocks.



Location Map of the North Sacramento Valley Ecological Management Zone and Units.

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE NORTH SACRAMENTO VALLEY ECOLOGICAL MANAGEMENT ZONE
■ spring-run chinook salmon
■ winter-run chinook salmon
■ fall-run chinook salmon
■ late-fall-run chinook salmon
■ steelhead trout
■ lamprey
■ native anuran amphibians
■ native resident fishes
■ neotropical migratory birds

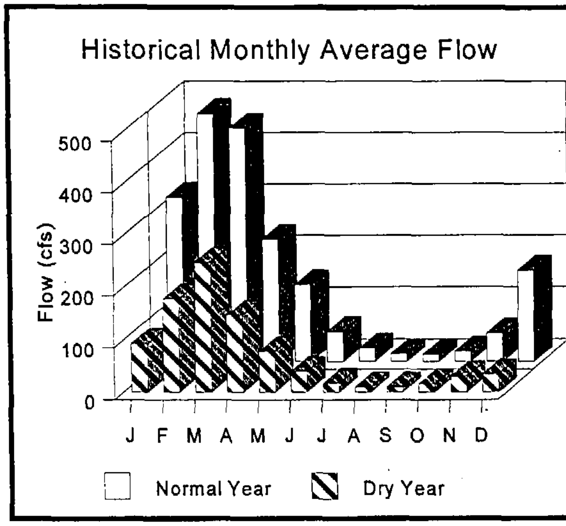
DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

CLEAR CREEK ECOLOGICAL MANAGEMENT UNIT

Clear Creek is a major tributary to the Sacramento River and drains approximately 238 square miles. It originates in the mountains east of Trinity Lake and flows into the Sacramento River near Redding. Whiskeytown Reservoir stores natural creek flows and water diverted from the Trinity River at Lewiston Dam through the Clear Creek Tunnel. Whiskeytown Dam, constructed in 1963, is 10 miles upstream of McCormick Dam. Whiskeytown Dam diverts more than 80% of Clear Creek's average natural flow to the Spring Creek Powerhouse at Keswick Reservoir on the Sacramento River.

The Clear Creek watershed has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate from foothills instead of the Cascade or Sierra crests. The stream is nearly dry during summer and fall months of low rainfall years. In wettest years, flows in winter months average 1,000 to 2,500 cubic feet per second (cfs). In winter months of dry years, average monthly flows reach only 100 to 250 cfs. In the driest years, winter monthly average flows reach only 20 to 35 cfs. Whiskeytown Dam, at the lower end of the watershed, receives water diverted from the Trinity River by way of the Clear Creek Tunnel.

A value planning study by the U.S. Bureau of Reclamation (1999) found that from 1941 through 1963, Clear Creek, prior to the construction of Whiskeytown Dam, experienced floods of 6,000 cfs or greater at least every 3 to 5 years. Larger floods of 9,000 cfs or greater were experienced about four times, and three times floods occurred greater than 14,000 cfs. After completion of the dam in 1963, flood flows of 6,000 cfs were experienced twice, 8,500 cfs once, and one flood of 14,000 cfs occurred once (U.S. Bureau of Reclamation 1999).



Clear Creek Streamflow, 1952-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Most of the Clear Creek and Trinity River water is conveyed from Whiskeytown Lake to Keswick Reservoir on the Sacramento River through the Spring Creek Tunnel. Flows in Clear Creek below Whiskeytown Lake are maintained at 50 cfs from January through October and 100 cfs in November and December, regardless of flow in the upper watershed. Approximately 10 cfs are diverted from the lower river at McCormick Dam, 8 miles upstream of the confluence with the Sacramento River.

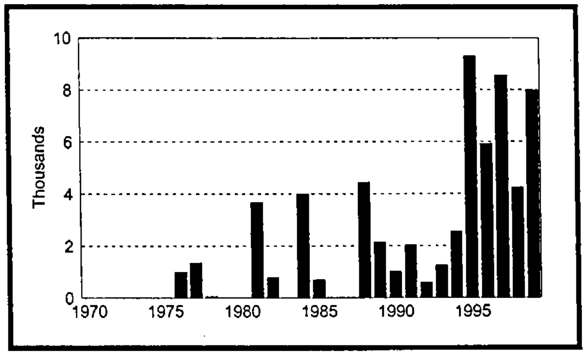
Spawning gravel in the lower Clear Creek drainage has been significantly depleted by mining. Because recruitment of new gravel into this area is restricted by McCormick and Whiskeytown dams, Shasta County adopted an ordinance in 1977 prohibiting new gravel mines in Clear Creek below McCormick Dam. Although the future of this ordinance is uncertain, it constitutes the best protection for spawning gravel. The existing gravel mining operations have refrained from mining in the floodplain for more than 4 years, allowing some riparian reforestation to occur naturally.

Before the construction of Whiskeytown Lake, Clear Creek delivered large amounts of gravel to the lower alluvial reaches and the Sacramento River. Flow regulation since 1963 has greatly reduced the frequency of floodflows capable of moving bedload. The instream gravel is not renewable, because gravel from the upper reaches is trapped in the reservoir. Flow regulation has also allowed dense stands of vegetation to encroach on the main channel, particularly the lower 3 miles before the confluence. This vegetation further reduces velocities and the gravel transport capacity of the stream.

In 1980, the California Department of Water Resources (DWR) estimated that the average annual instream extraction rate of sand and gravel was approximately 75,000 tons per year, equivalent to 20 times the natural transport rate. Subsequent field observations in 1980 and 1994 suggest that gravel mining, flow regulation, and vegetative encroachment combined to reduce the available gravel in Clear Creek. The average annual contribution of gravel to the Sacramento River was estimated to be approximately 5,000 tons per year. In recent year years, gravel operators have halted the practice of instream mining. During this same period, gravels were distributed to the spawning area from tributary stream sources, stream meander, and artificially introduced gravel stockpiles. At this time there are two completed gravel injection projects and one in progress.

Spawning habitat restoration work in Clear Creek is necessary. The work will require placing spawning gravel at appropriate locations. Implementing this restoration will require monitoring spawning gravel to determine whether it successfully meets the needs of adult salmon and steelhead. The CVPIA Clear Creek Restoration Program is addressing poor instream spawning habitat resulting from gravel mining and blockage by Whiskeytown Dam. Habitat is being improved with spawning gravel introduction. Gravel is being placed below Whiskeytown and Saeltzer dams every years. This gravel injection program is expected to continue indefinitely.

The abundance of fall-run chinook salmon spawners in Clear Creek has increased during recent years when the fall flows have been increased by a factor of three. During this interim flow increase, the spawning population estimates have been between 7,000 and 9,000 representing 5% to 8% of the upper Sacramento River salmon population. In 1998, the entire AFRP recommended flows from Whiskeytown Reservoir were provided. This resulted in significant benefits to chinook salmon escapements, habitat availability, and water quality. In 1998, the fall-run chinook salmon escapement was estimated at 4,258 fish. Since flows were first increased in 1995, the average fall-run chinook return has increased 400 percent.



Clear Creek Fall-run Chinook Salmon Returns, 1970-1999 (CDFG 1999).

Spring-run chinook could have historically migrated to the uppermost reaches of Clear Creek above the town of French Gulch (Yoshiyama et al. 1996). In 1956, Azevedo and Parkhurst (1958) saw spring-run chinook in Clear Creek for the first time since 1949. Passage to the upper watershed was severely restricted by the construction of McCormick-Saeltzer Dam around the turn of the century, then completely eliminated by the construction of Whiskeytown Dam in 1964. It is likely the steelhead also ascended Clear Creek at least as far as French Gulch.

In spite of improved conditions, there are no spring-run chinook salmon in Clear Creek (California Department of Fish and Game 1998) and the status of the steelhead population is unknown. Habitat in Clear Creek has the potential to support spring-run chinook and steelhead if passage at McCormick-Saeltzer Dam is improved to allow adult fish access to the stream reach immediately below the Whiskeytown Dam. Operation of the dam can provide suitable cold-water habitat downstream to allow adult spring-run chinook to oversummer and then spawn in the fall. The cold water would also support juvenile salmon and steelhead rearing through the summer.

Restoring habitat and increasing flow releases from Whiskeytown Reservoir could significantly improve